

WHAT IS CLAIMED IS:

- 1 1. A system for injecting one or more additives into production fluid
2 produced by at least one subsea well, the system comprising:
3 a) a surface chemical supply unit for supplying at least one
4 chemical to a selected subsea location;
5 b) at least one chemical supply line for carrying the at least one
6 chemical from the surface to the selected subsea location; and
7 c) a subsea chemical injection unit at the selected subsea location
8 receiving the at least one chemical from the surface chemical
9 supply unit and selectively injecting the at least one chemical
10 into the production fluid.
- 1 2. The system of claim 1 further comprising a controller that controls the
2 amount of the at least one chemical injected in response to at least one
3 parameter of interest.
- 4 3. The system of claim 1 wherein the parameter of interest is one of (i)
5 temperature, (ii) pressure, (iii) flow rate, (iv) a measure of one of
6 hydrate, asphaltene, corrosion, chemical composition, wax or
7 emulsion, (v) amount of water, and (vi) viscosity.
- 1 4. The system of claim 3 further comprising at least one sensor for
2 providing information about the at least one parameter interest, said at
3 least one sensor being selected from a group consisting of a
4 temperature sensor, a viscosity sensor, a fluid flow rate sensor, a
5 pressure sensor, a sensor to determine chemical composition of the
6 production fluid, a water cut sensor, an optical sensor, and a sensor to
7 determine a measure of at least one of asphaltene, wax, hydrate,
8 emulsion, foam and corrosion.
- 1 5. The system of claim 1 wherein the subsea chemical injection unit
2 includes a storage unit for storing the at least one chemicals supplied
3 by the surface chemical supply unit.

- 1 6. The system of claim 5 wherein the at least one chemical supply line
2 includes a plurality of lines for carrying a plurality of chemical to the
3 subsea chemical injection unit.
- 1 7. The system of claim 6 wherein the surface chemical supply unit
2 supplies a plurality of chemicals to the subsea chemical injection unit
3 via the plurality of lines.
- 1 8. The system of claim 1 wherein the surface chemical supply unit is
2 located on an offshore rig.
- 1 9. The system of claim 1 wherein the surface chemical supply unit
2 includes a buoy at the sea surface and wherein the at least one
3 chemical supply line carries chemicals from the buoy to the selected
4 subsea location.
- 1 10. The system of claim 9 wherein the buoy includes a chemical storage
2 unit that is periodically filled.
- 1 11. The system of claim 10 wherein the at least one supply line includes a
2 plurality of supply lines, one for each chemical, between the buoy and
3 the selected subsea location.
- 1 12. The system of claim 1 wherein the subsea chemical injection unit
2 further comprises a manifold for mixing at least two chemicals prior to
3 injecting the at least two chemicals into the production fluid.
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1 13. The system of claim 1 wherein the subsea chemical injection unit
2 comprises one of a control valve and control pump for controlling the
3 amount of the at least one chemical injected into the at least one
4 subsea well.

- 1 14. The system of claim 1 further comprising a subsea power unit for
2 supplying power to the chemical injection unit.
- 1 15. The system of claim 14 wherein the subsea power unit includes an
2 electrical battery that is periodically charged from energy supplied from
3 a surface location.
- 1 16. The system of claim 1 further comprising a riser for transporting
2 production fluid to the surface and wherein the at least one chemical
3 supply line is located at one of (i) inside the riser, and (ii) outside the
4 riser.
- 1 17. The system of claim 1 further comprising a plurality of sensors
2 distributed along a production fluid path.
- 1 18. The system of claim 4 wherein the at least one sensor is located at one
2 of (i) wellhead over the at least one wellbore, (ii) in the wellbore, and
3 (iii) in a supply line between the wellhead and the subsea chemical
4 injection unit.
- 1 19. The system of claim 1 wherein the at least one subsea well includes a
2 plurality of wells and the subsea chemical injection unit separately
3 supplies the at least one chemical to each said subsea well.
- 1 20. The system of claim 1 further comprising a subsea fluid-processing unit
2 receiving the production fluid via a line.
- 1 21. The system of claim 1 wherein the subsea chemical injection unit
2 injects the at least one chemical into one of (i) the at least one subsea
3 well, (ii) a subsea fluid processing unit, and (iii) in a subsea pipeline
4 carrying the production fluid.
- 1 22. The system of claim 1 further comprising a heating device deployed
2 subsea to heat the production fluid.

1 23. The system of claim 1 further comprising a surface controller for
2 controlling one of: (i) at least in part the operation of the subsea chemical
3 injection unit and (ii) the supply of the at least one chemical.

1 24. The system of claim 23 further comprising a remote controller providing
2 command signals to the surface controller to control the injection of the
3 at least one chemical.

1 25. The system of claim 1 further comprising a plurality of distributed
2 sensors associated with said at least one chemical supply line for
3 providing signals relating to a characteristic of the at least one chemical
4 carried by the at least one chemical supply line.

1 26. The system of claim 25 wherein the surface chemical supply unit controls
2 the supply of the at least one chemical in response to the signals relating
3 to the characteristic of the at least one chemical in the supply line.

1 27. The system of claim 22 further comprising a power unit at the surface
2 that provides power to the heating device.

1 28. The system of claim 20 wherein the processing unit refines at least
2 partially the production fluid.

1 29. the system of claim 28 further comprising a fluid line carrying
2 processed fluid from the processing unit to the surface.

1 30. A flow assurance method for fluid produced ("production fluid") by at least
2 one subsea well comprising:
3 a) providing a surface chemical supply unit at a location remote from
4 the at least one subsea well for supplying at least one chemical to
5 a selected subsea location;
6 b) providing at least one chemical supply line for carrying the at least
7 one chemical from the surface to the selected subsea location;

8 c) measuring a parameter of interest relating to a characteristic of the
9 production fluid; and
10 d) providing a subsea chemical injection unit at the selected
11 subsea location for receiving the at least one chemical from the
12 surface chemical supply unit via the at least one chemical
13 supply line and for selectively injecting the at least one chemical
14 into the production fluid, at least in part in response to the
15 parameter of interest.

1 31. The method of claim 30 wherein measuring the parameter of interest
2 includes measuring one of temperature, viscosity, fluid flow rate,
3 pressure and chemical composition of the produced fluid, a measure of
4 asphaltene, wax, hydrate, emulsion, foam, corrosion, or water, and an
5 optical property of the production fluid.

1 32. The method of claim 30 further comprising locating an end of the at
2 least one chemical supply line at a buoy at the water surface.

1 33. The method of claim 32 further comprising moving the surface
2 chemical supply unit to the buoy to supply the at least one chemical to
3 the subsea chemical injection unit via the at least one supply line.

1 34. The method of claim 32 wherein the at least one supply line includes a
2 plurality of supply lines and the surface chemical supply unit pumps a
3 separate chemical through each of the plurality of supply lines.

1 35. The method of claim 30 wherein the subsea chemical injection unit
2 includes: (i) a pump for injecting the at least one chemical into the production
3 fluid; (ii) a flow control valve; and (iii) a controller that controls the flow control
4 valve to control the amount of chemical injected into the at least one subsea
5 well.

1 36. A system for injecting a chemical into formation fluid produced by at
2 least one subsea well, comprising: (i) a chemical supply system for supplying
3 a desired chemical; and (ii) an underwater chemical injection unit injecting
4 chemical into the formation fluid produced by the at least one subsea well.

1 37. The system of claim 36 further comprising at least one sensor
2 providing a measurement of a parameter of interest.

1 38. The system of claim 37 wherein the underwater chemical injection
2 unit includes a controller that controls at least in part the injection of the
3 chemical in response to the parameter of interest.

1 39. The system of claim 37 wherein the parameter of interest is one of
2 interest in one of: (i) a physical property of the formation stored; (ii) a chemical
3 property of the formation fluid; or (iii) a parameter relating to a device
4 associated with the at least one subsea well.

1 40. The system of claim 36 wherein the chemical injection unit injects
2 the chemical at one of: (i) at a location within the at least one wellbore, and
3 (ii) at a location at the seabed.

1 41. The system of claim 37 wherein the chemical supply system
2 includes: (i) an underwater storage tank for storing the chemical therein; and
3 (ii) a chemical supply unit at the sea surface that supplies the chemical to the
4 underwater storage tank.

1 42. The system of claim 36 wherein the chemical supply system
2 includes an underwater chemical storage tank that is adapted to be one of: (i)

- 3 refillable by a remotely operated device and (ii) replaceable via a quick
- 4 disconnect.